

SCIENCE FOR GLASS PRODUCTION

UDC 666.11:691.6:535.3

PARTICULARS OF DETERMINING THE SOLAR CHARACTERISTICS OF GLASS

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Direct calculations of the solar radiation transmission based on different standards have been performed for several types of glass and the discrepancy in the data obtained is evaluated as a function of the optical properties of the glass.

Key words: glass, direction solar transmission, standards, calculations, analysis.

The character of the interaction of glass with solar radiation depends on the optical properties of the glass that determine its radiation transmission, reflection, and absorption in different wavelength ranges, which determines the applicability of glass in building designs, buildings, and structures. These parameters (optical characteristics) must be taken into account in the required order in glasswork design [1]. One of the most important optical characteristics is the transmission, reflection, and absorption in the range that includes UV, visible, and near-IR regions of the spectrum, the so-called direct solar transmission, direct solar reflection, and direct solar absorption.

Several international standards are currently used to determine these parameters. Aside from the spectral characteristics of glass, the computational procedure (identical in all standards with the exception of the volume of the calculations) uses data on the spectral distribution of the solar radiation. However, following CIE (International Commission on Illumination — CIE is from the French name Commission Internationale de L'Eclairage), the conditions under which data on the spectral distribution of the solar radiation are presented are different in different currently operative standards and, correspondingly, the data themselves are different. This can result in discrepancies between the results obtained using different standards. As a result of discrepancies, even very small ones, the question can arise as to whether or not the glass meets the appropriate requirements, which, in turn, can result in disputes between suppliers and users. In addition, these discrepancies likewise can result in discrepancy in thermal and optical calculations of the glasswork.

To evaluate the possible discrepancies we have performed calculations of the most important of the indicated characteristics — the direct solar transmission of several types of glass according to some of the most widely used standards. Analysis of the results will make it possible to obtain a better sense of the data provided by different glass producers. The calculations were performed on the basis of the following (most widely used) standards: I) ISO 1990 according to CIE [range 300–2500 nm, 20 computed points, AM³ (air mass) = 1];⁴ II) ISO 1990 according to Moon [2] (350–2100 nm, 36 points, AM = 2), III) EN-410 (300–2500 nm, 56 points, AM = 1), IV) ISO 2003 (300–2500 nm 95 point, AM = 1.5), V) ISO 2003, but the number of computed points (20) and their values are similar to ISO 1990. The objective of the last variant is to determine whether or not the simplified calculation using 20 points instead of 95 is admissible, since the calculation using 95 points is a very laborious procedure if access to modern equipment making it possible to automate this process is not available, and it is no secret that more than just a few people are still interested in the simplified variant.

The appropriate conversion and normalization of the values of the spectral distribution of the spectral distribution of the total solar radiation were performed in order to transition

³ Air mass (AM) — ratio of the atmospheric mass present in the real-observer — sun direction to the atmospheric mass which would be present immediately above an observer located at sea level at the standard barometric pressure. Otherwise, AM is the ratio of the direct path of a solar ray through the atmosphere with the sun at the zenith angle Z with respect to the path of the ray when the sun is directly above the observer.

⁴ Similar data for calculating the direct solar transmission are present in the standard DIN 67597.

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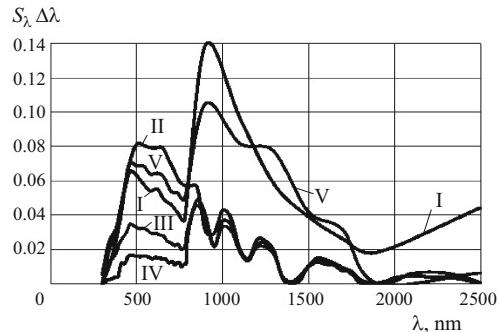


Fig. 1. Curves of the normalized relative spectral distribution of the global solar radiation S_λ , multiplied by the wavelength interval $\Delta\lambda$, according to different standards: I) ISO-9050 (1990, CIE); II) ISO-9050 (1990, Moon); III) EN-410; IV) ISO-9050 (2003); V) ISO-9050 (2003, simplified variant).

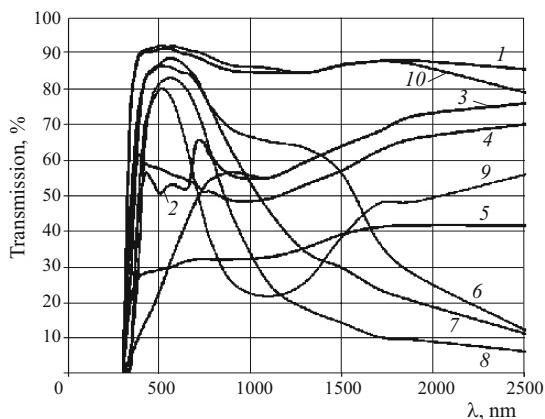


Fig. 2. Character of the transmission spectra of the experimental samples; the numbers on the curves are the sample numbers.

to 20 points. The spectral distribution curves of the total solar radiation which are used in different standards are presented in Fig. 1. The calculations were performed for glass with different spectral characteristics: for colorless and colored with absorption predominating either in the blue or in the red parts of the spectrum as well as for coated glass. The transmission spectra of the samples studied are presented in Fig. 2. The curve of the spectrum was recorded using SF-26 (300 – 1200 nm) and IKS-14A (750 – 2500 nm) spectrophotometers. The computational results are presented in Table 1.

Analysis of the results shows that for colorless glass or glass with approximately the same level of transmission in the wavelength studied and in which no decrease of transmission occurs in the low-wavelength region of the spectrum there is no fundamental difference in the standard used to calculate the transmission — the maximum discrepancy is no more than 2% (and not only for one glass but for nine types of glass). The discrepancy in the calculations using the “new” ISO and its simplified variant does not exceed 1% for such glasses. Likewise, the discrepancies in data according to the “new” ISO and EN-410 standards do not exceed 1%. A larger difference in the computational results is seen only for glasses in which the transmission is strongly reduced in the

TABLE 1.

Glass sample	Direct solar transmission according to different standards				
	I	II	III	IV	V
1	87	88	88	88	88
2	55	55	55	56	55
3	43	44	42	43	42
4	54	54	54	54	54
5	33	33	33	33	33
6	70	74	73	73	75
7	64	69	67	67	69
8	52	57	56	56	57
9	49	50	51	50	51
10	88	89	88	88.5	89

direction of the IR region of the spectrum. The maximum discrepancy for them is 5%. Basically, the largest deviations are observed when comparing data obtained using the ISO 1990 (CIE) and ISO 2003 standards (although large discrepancies are also present in calculations using the two variants of the ISO standard — according to CIE and Moon); the difference for the two variants of the “new” ISO is 2% and the difference between the ISO 2003 and EN-410 is 1%.

In summary, the result obtained show that the calculations performed using the two currently operative standards, ISO-9050 (2003) and EN-410, are not fundamentally different. It can also be concluded that calculations performed according to the ISO 2003 variant are fully admissible, especially for colorless glass. The cases where special accuracy is required or where strongly expressed selected absorption is present in the spectra of the glass are exceptions.

The present results are not absolutely unqualified, since their statistical base is not very large. Nonetheless, they can make it possible to get a bearing on the glass characteristics presented. Of course, the approach to be used for existing data should be carefully considered in each specific case.

A formulation of the question of the (full) acceptability of the calculations using the latest international standard ISO 9050 for all regions of Russia has not been ruled out. The problem is that the data adopted in this standard for the spectral distribution of the solar radiation best correspond to the geographic position of the US ($30 - 50^\circ$ NL) and Western Europe ($40 - 55^\circ$ NL). Russia mainly lies in more northern latitudes ($50 - 70^\circ$), to say nothing of more northern regions, such as the Nenetskii Autonomous Region or the Taimyr Peninsula (up to 80° NL). Consequently, the validity of ISO 9050 calculations for all regions in Russia requires additional analysis.

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